Visualization of NASA A-Train Vertical Data on Google Earth™

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NASA/GES DISC Google Earth™ Portal
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Overview

Google Earth™ combines satellite imagery, aerial photography, map data, and socio-economic data to present an interactive 3D portrayal of the world. It is not only popular to general public, but also helping scientists discover, add, and share geographic data/information easily. NASA GES DISC is integrating NASA imagery in Google Earth in order to facilitate Earth scientific research and , including a web portal to introduce and display the results (right figure). A general framework is proposed for rendering and displaying both 2D mapped data and 3D vertical profiles in Google Earth. The 2D data can be processed via OPeNDAP (Open Source Project for a Network Data Access Protocol) and standard Open Geospatial Consortium's WMS (Web Map Service) or GES DISC's Giovanni to produce images that are displayed in Google Earth.

However, 3D vertical profiles are first processed via Giovanni A-Train instance to produce image curtains. The image curtains are chopped into small slices and each slice is put onto a generalized COLLADA 3D model as the texture of the model. Using those COLLADA models and satellite orbit coordinates, an orbit curtain model is implemented in KML format. The resultant orbit curtain makes vertical data viewable in Google Earth. The 3D vertical profiles are from CloudSat, CALIPSO, and Aqua MODIS and AIRS to address cloud, aerosol, and H2O characteristics and atmospheric temperature profiles in the form of curtain along the satellite orbit. Simultaneous visualization and efficient exploration of the relationships among quantitative geospatial data becomes possible.

- HDF-EOS files
- Image curtain plot via Giovanni version 3 – A-Train system
- Orbit curtain slice plot via COLLADA model
- Orbit curtain plot via KML

Procedures of visualizing vertical data on Google Earth

NASA A-Train Constellation Formation

The A-Train

The NASA **Afternoon A-Train Satellite Constellation** is a succession of seven US & international sun-synchronous orbit satellites, consisting of:
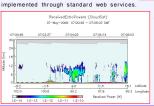-- **OCO** (Orbiting Carbon Observatory) (not launched yet);
-- **Aqua**; -- **CloudSat**;
-- **CALIPSO** (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations);
-- **PARASOL** (Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a Lidar) (A French mission);
-- **Glory**; and -- **Aura**.

It makes possible synergy of information from multiple resources, so that more information about the earth condition is obtained from the combined observations than would be possible form the sum of the observations taken independently [NASA Facts].

Giovanni V3 and its produced image curtain

Right: Giovanni A-Train online interface:
http://disc.gsfc.nasa.gov/atdd

Giovanni provides a convenient and useful platform for bridging the geospatial imagery data with the implied science and explicitly displaying the results to scientific communities. Giovanni Version 3 (G3) adopts service- and workflow-oriented asynchronous architecture. Standard protocols, such as FTP, OPeNDAP, GrADS Data Server, help G3 transparently work with local and remote data. Service-Oriented Architecture guarantees that data processing and rendering modules are implemented through standard web services.
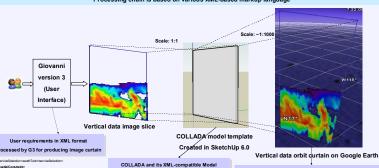
Right now, Giovanni A-Train instance can process following physical parameters:
-- Atmospheric temperature (AIRS/MODIS-Aqua)
-- H2O saturation/vapor mass mixing ratio (AIRS)
-- Retrieved dew point temperature profile (MODIS)
-- Cloud/aerosol classification (VFM) (CALIPSO)
-- Received echo powers/reflectivity dBZ (CloudSat)
-- RO ice/liquid water content (CloudSat)

Left: Image curtain of cloud vertical profile from A-Train CloudSat satellite, rendered via Giovanni v3.

ReceivedEchoPowers (CloudSat)
07-May-2008 07:00:48 – 07:08:03 GMT

Rendering Vertical Data Orbit Curtain on Google Earth™

General Solutions for Serving and Rendering Earth Science Data on Google Earth™

Geospatial Data i.e. HDF, NetCDF → Other Data Protocols, OGC WCS, THREDDS, GrADS, OPeNDAP, FTP, HTTP/FTP → OGC WMS (UMN / G3) → Data themselves → Models → Images → KML/KMZ

Legends
HDF: Hierarchical Data Format
OGC: Open Geospatial Consortium
GrADS: Grid Analysis and Display System
THREDDS: Thematic Real-time Environmental Distributed Data Services
OPeNDAP: Open-source Project for a Network Data Access Protocol
HTTP: Hypertext Transfer Protocol
NetCDF: network Common Data Format
WCS: Web Coverage Service
WMS: Web Map Service
FTP: File Transfer Protocol

From Image Curtain to COLLADA Model to Orbit Curtain on Google Earth™

Processing chain is based on various XML-based markup language

Giovanni version 3 (User Interface)

Vertical data image slice
Scale: 1:1
Scale: ~1:1000
COLLADA model template Created in SketchUp 6.0
Vertical data orbit curtain on Google Earth

User requirements in XML format processed by G3 for producing image curtain

COLLADA and its XML-compatible Model with image texture (*.dae)

Orbit Curtain in KMZ format, including KML, images, COLLADA models, and texture files

Part of KML codes for one slice of image curtain

Part of texture file

A-Train Vertical Data on Google Earth™

Left: GMT 5:32–5:42 May 14, 2008
Orbit curtain with fake scale for Cloud Received Echo Power from CloudSat data

Right: GMT 5:32–5:42 May 14, 2008
Orbit curtain with fake scale for Cloud/Aerosol Classification (Vertical Feature Mask) (Calipso-lidar) from CALIPSO data
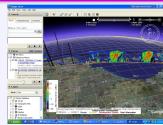
Specific Cases from A-Train Vertical Data

California Fire on Oct. 20, 22, 24, 25, 2007 Cloud/Aerosol Classification & IceWater Phase Discrimination from CALIOP/CALIPSO

Tropical Storm Andrea near SC/GA/FL Atlantic coast on May. 9, 2007 Cloud and Aerosol from CloudSat and CALIPSO

Heavy Tropical Rains over China's southern coast on Jun. 9 and 11, 2007 cloud and aerosol data from CloudSat and CALIPSO

Intense precipitation over the Arabian Sea near Pakistan on 25 June 2007 cloud and aerosol data from CloudSat and CALIPSO

Synergy of 2D and 3D Earth data on Google Earth™

Left: GMT 12:00pm – 1:30pm Feb. 23, 2007
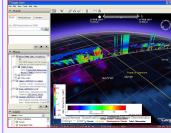3-hourly (10:30am – 1:30pm) .25°x.25° rainfall data from TRMM
AND Cloud Reflectivity (dBZ) from 1B-CPR/CloudSat
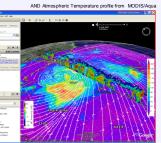AND Cloud/Aerosol Classification from CALIPO/CALIPSO
AND Atmospheric Temperature Profile from MODIS/Aqua

Right: GMT 12:00:00pm – 1:00:00pm Feb. 23, 2007
Cloud Reflectivity (dBZ) from 1B-CPR/CloudSat
AND Cloud/Aerosol Classification from CALIOP/CALIPSO
AND Atmospheric Temperature profile from MODIS/Aqua

Left: GMT 5:48:00am – 5:55:00am 2006-08-02
Vertical orbit curtain describing cloud vertical structure (Radar Reflectivity, dBZ) derived from CloudSat satellite,
and daily rainfall (3B42) from TRMM satellite,
and wind field from QuikSCAT satellite
for **Typhoon Prapiroon**.

Conclusion

This solution allows a researcher to combine vertical data together with other geospatial data for scientific research. This ability to visualize and compare diverse data from different providers provides researchers with a novel and valuable tool for data exploration.